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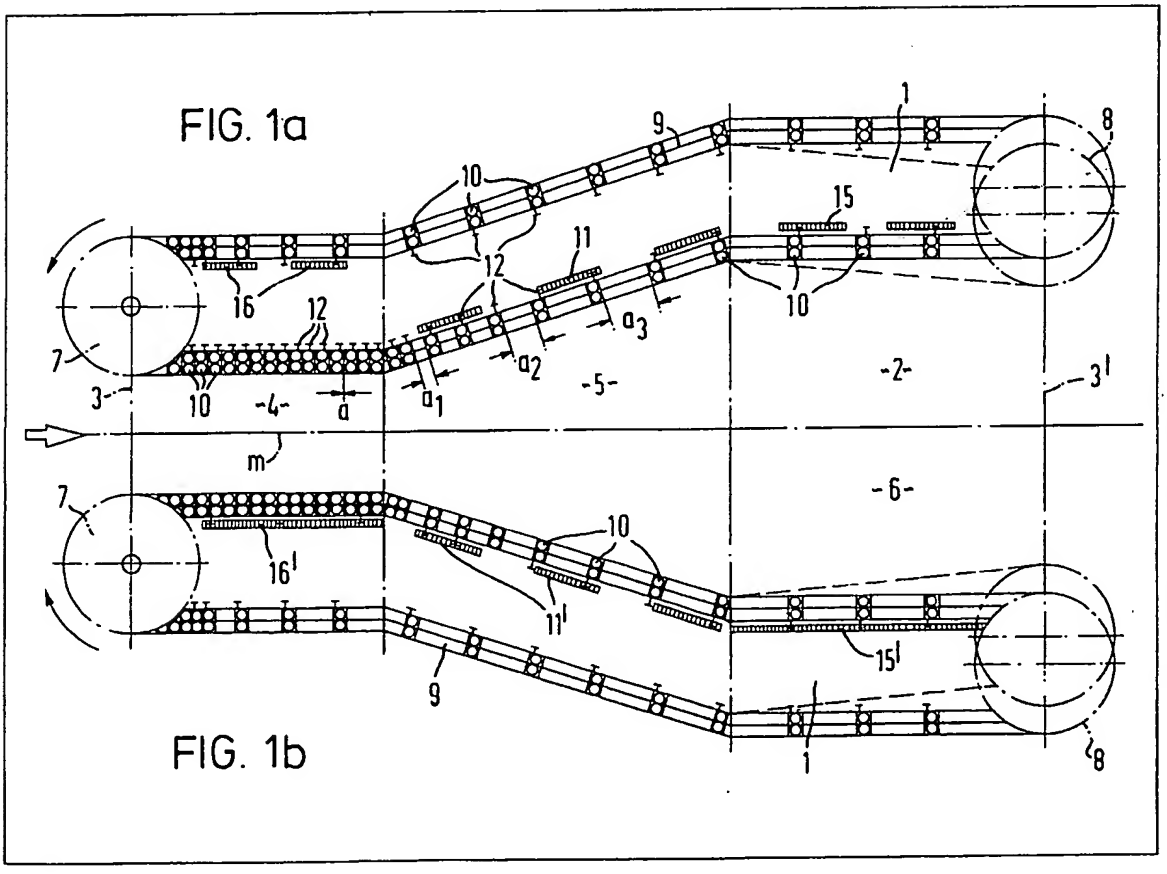
(54) **Foil stretching apparatus**

(57) A biaxial foil stretching apparatus (Figures 1a and 1b) has two tracks (1). Tentering clips (10) are mounted on each track (1) and driven by a continuously rotating drive chain (9). The longitudinal spacing between adjacent clips (10) is variable by gearing between each clip and the drive chain. Operation of the gearing is activated by engagement between a pinion 12 on each clip and a rack 11 mounted beside the track.



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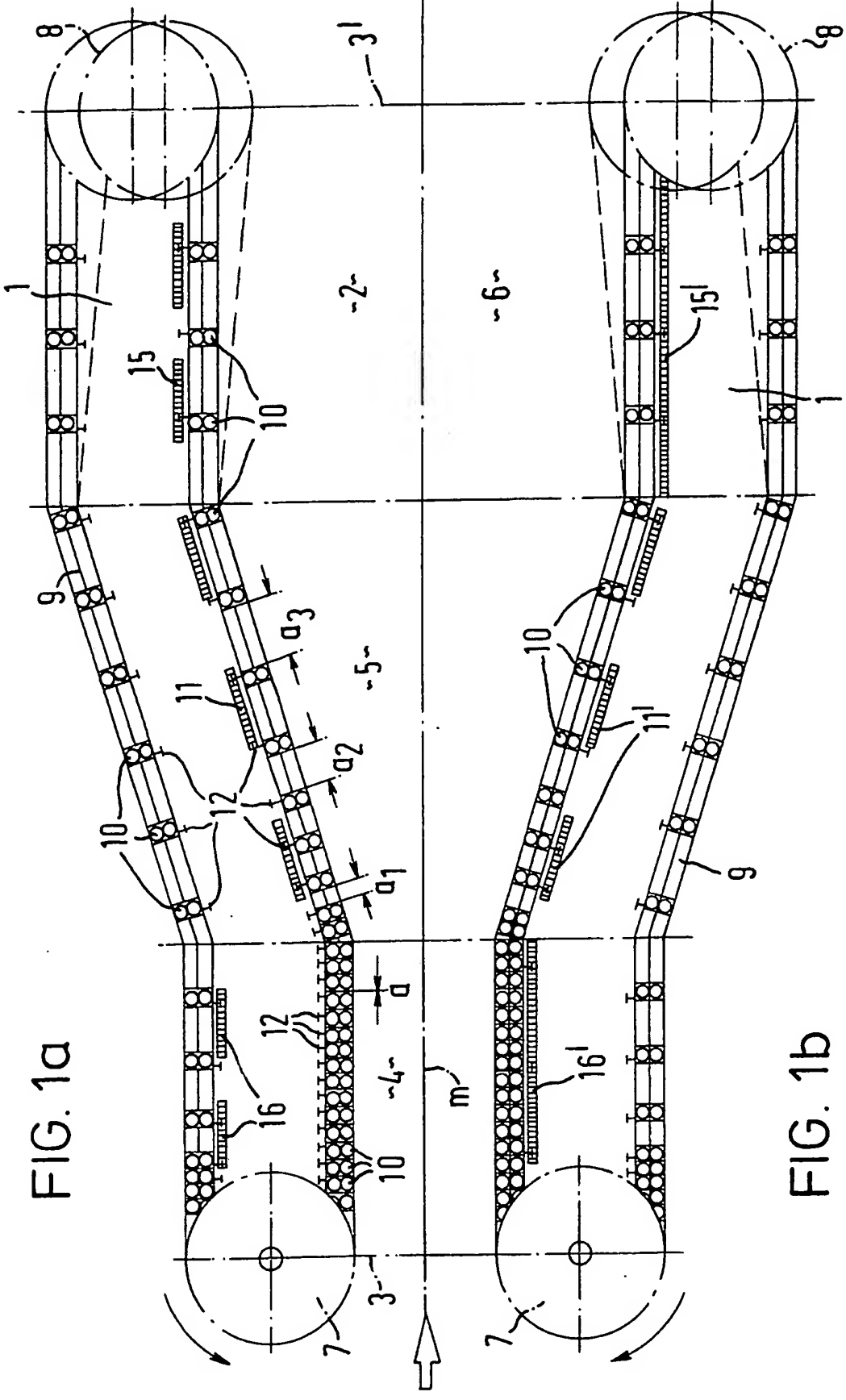

FIG. 1a

FIG. 1b

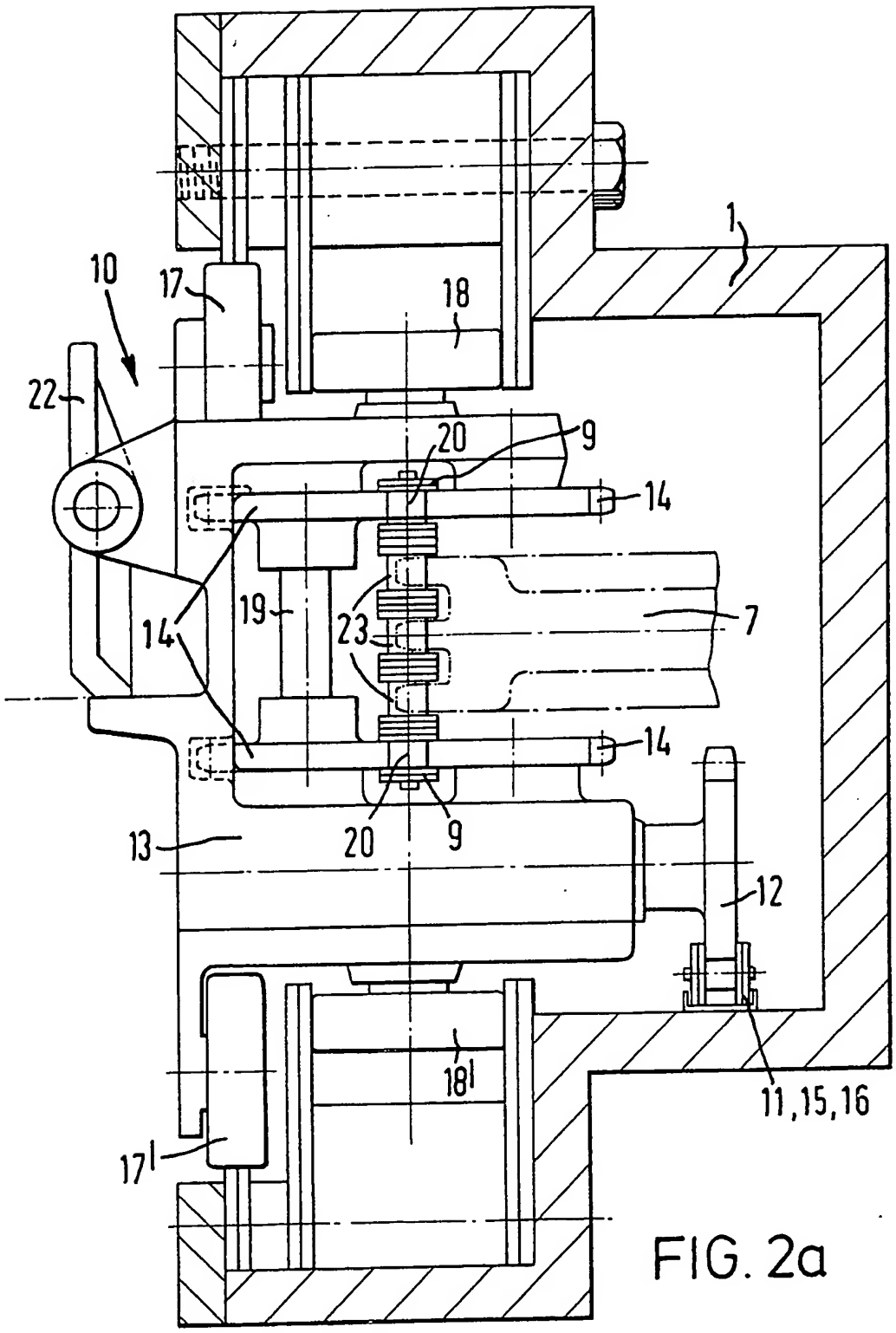

FIG. 2a

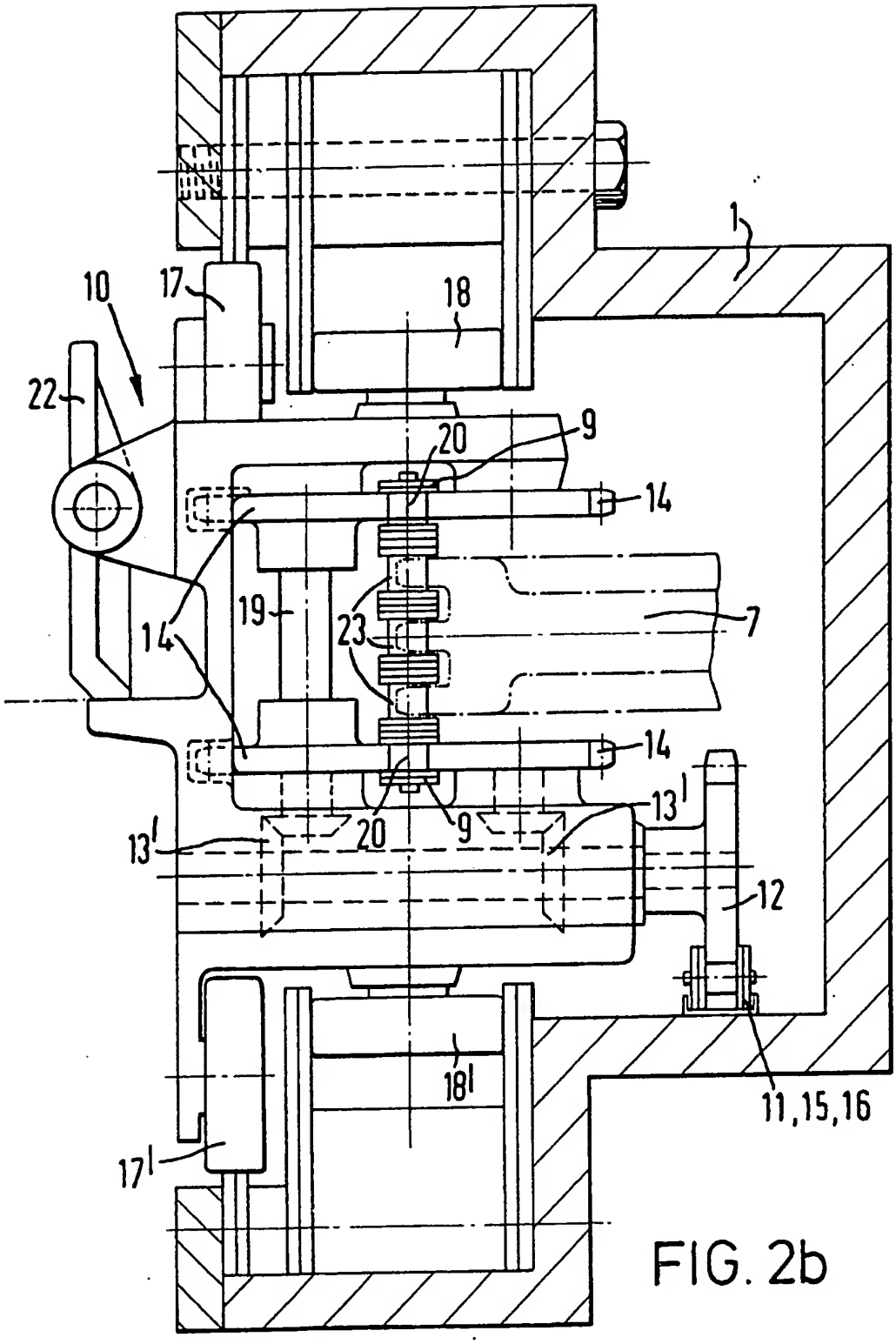

FIG. 2b

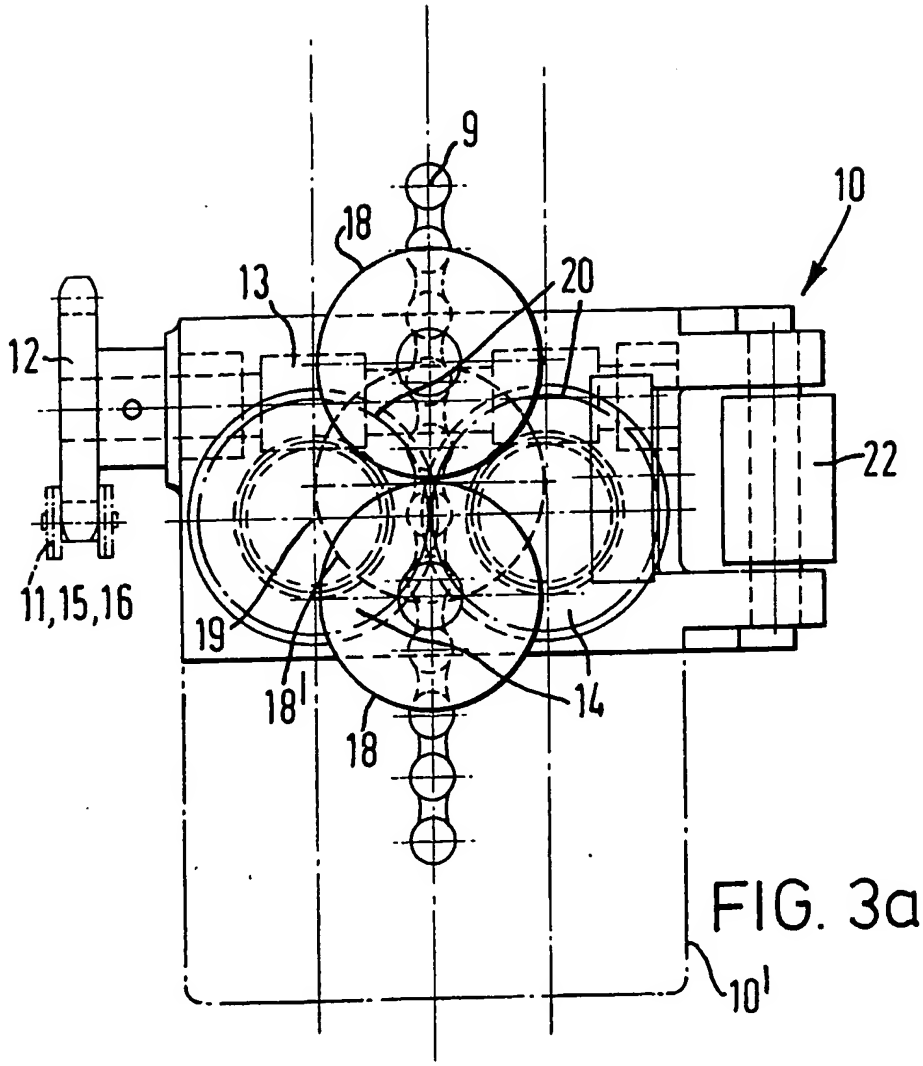

FIG. 3a

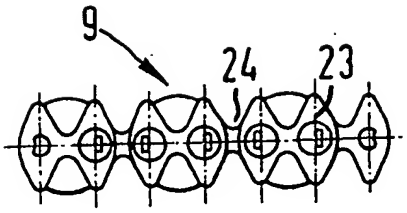

FIG. 4

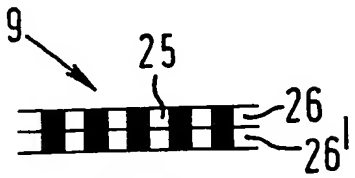

FIG. 5

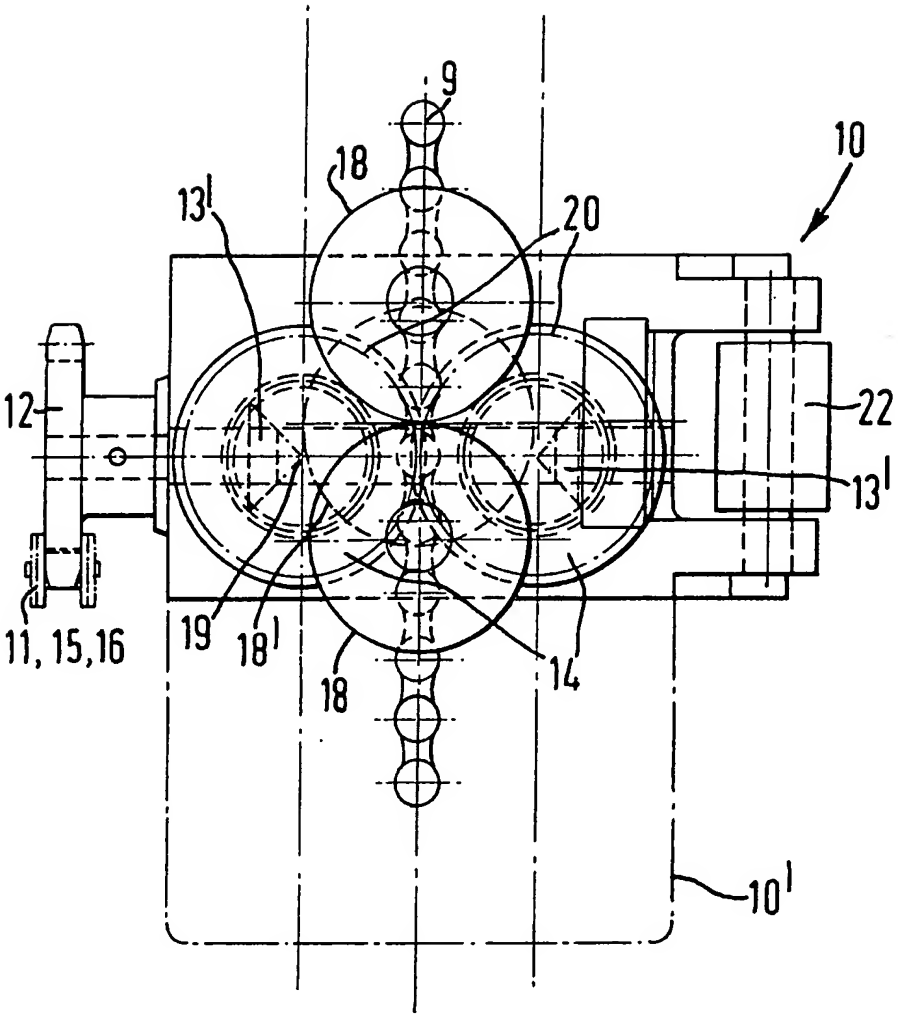

FIG. 3b

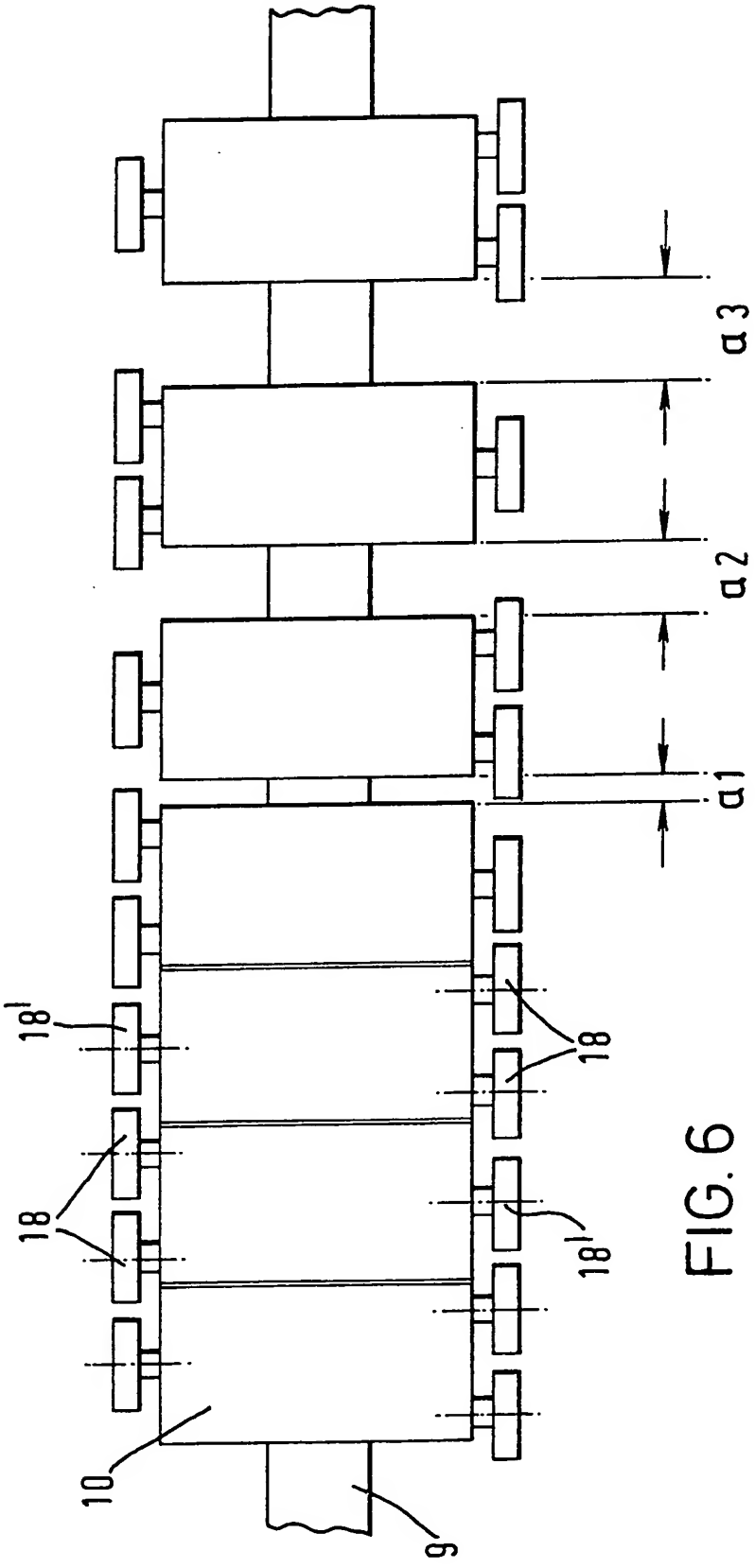

FIG. 6

SPECIFICATION

Foil stretching apparatus

This invention relates to an apparatus for stretching foil.

Apparatus known for stretching plastics foil, in particular for biaxial stretching, uses devices for continuously increasing the distance between the adjacent tentering means, which may be tenering clips or other gripping devices, on a traction device during the stretching operation. According to DE-AS 16 29 562, for example, two endless link conveyors with successive tentering clips are arranged on each side of the foil web. In this arrangement, the clips are connected together by guide rods arranged in zig-zag formation along the two guide tracks in the stretching and fixing zone. The space between the two guide tracks decreases in the stretching zone and increases in the fixing zone. One feature of this arrangement which is disadvantageous and complicated is that any alteration in the longitudinal stretching ratio or the longitudinal shrinkage ratio can only be achieved by altering the positions of the two guide tracks in relation to each other. In an apparatus disclosed in German Patent No. 1 259 558, the stretching devices consisting of individual tentering clips are joined by springs acting in the direction of travel. The disadvantage of this arrangement is that owing to the differing spring forces of the springs joining the individual clips together, accurate adjustment of the stretching ratios in the longitudinal direction cannot be achieved. Owing to the inconstant spring forces, the longitudinal stretching ratio required for biaxial stretching cannot be varied.

Lastly, in an apparatus disclosed in German Patent No. 2 841 510 for the manufacture of a biaxially stretched foil web, each tentering clip has a drum on which connecting means can be rolled or unrolled, for altering the distance between clips. Each drum is connected to a sprocket wheel by way of a worm gear, and for winding or unwinding the connecting means, the sprocket wheel engages control drive chains which are arranged along the guide track and are independent of the clips. The main disadvantage of this arrangement is that the whole longitudinal force passes through all the clips, so that a considerable transmission and large dimensions are required. Moreover, the continuous bending of the connecting means as they are wound and unwound on the drum causes increased fatigue of the material and hence increased wear and fracture of the connecting means. This is in some cases connected with jamming of the traction device or of the clips arranged side by side in the guide tracks. Moreover, the arrangement of a drum for each clip requires a considerable amount of space, material and weight.

It is an object of the present invention to reduce the above-mentioned disadvantages and to provide for virtually infinite variation in the distance between adjacent clips or gripping devices without the individual clips or devices being jointed together by connecting means adapted to be wound up and unwound, and to enable the clips or devices to be transported independently of connecting means. With such an arrangement, the stretching and shrinkage ratio in the longitudinal direction should be virtually infinitely adjustable during stretching and shrinking.

According to this invention, apparatus for stretching a foil web comprises tentering clips driven on two guide tracks at respective side edges of the web to grip the edges, the distance between clips being adjustably variable, and each guide track having a continuously driven clip driving device, wherein clips are connected to the clip driving device by gear elements and by which gear elements clips are adjustably displaceable in the longitudinal direction of the clip driving device, the gear elements being operable from control means arranged along the guide track and independent of the clips.

An advantage of the invention is that longitudinal forces are only partly transferred to each clip and the main forces are introduced or act by way of the clip driving device.

The continuous increase in the size or length of the web during stretching in the stretching zone according to the given longitudinal stretching ratio causes the clips to follow at the speed of stretching in the direction of travel of the clip driving device. The clips which are still situated side by side in the heating zone must adapt themselves to this speed of stretching during their passage through the stretching zone. This means that the clips must continuously move further away from each other and their distance apart continuously increases until the predetermined longitudinal stretching ratio has been reached. The control required for this is a continuous control and may be brought about by pairs of sprocket wheels arranged one above the other in the clips, the teeth of which sprocket wheels engage with the clip driving device which is driven by deflecting and conveyor wheels, arranged at the respective ends of the heating and fixing zones. Driving of the pairs of sprocket wheels and hence infinite adjustment of distance may be brought about by a worm gear or pair of worm gears in each clip and a control sprocket wheel which is connected with the worm gear and is arranged with teeth in engagement with a clip drive chain. The clips with their worm gears and pairs of sprocket wheels connected thereto thus form a flexible, chain-like connection by means of the teeth meshing with the clip chain. The longitudinal stretching ratio can therefore easily be transmitted to the clips by way of the control drive chains, control sprocket wheels, worm gears and pairs of sprocket wheels, so that the distance between individual clips can be adjusted. At the same time, the web is carried through the treatment zone partly with its edges parallel and partly with its edges diverging. After the final stretched state has been reached in the stretching zone and during the passage of the stretched foil through the fixing zone, the foil shrinks to a certain extent. To compensate for this shrinkage and to keep the foil taut until the foil leaves the apparatus, the distances between the clips must be corrected, i.e. they must be reduced. This is achieved by control drive chains and by the control sprocket wheels

engaging with the drive chains and by means of the worm gears connected thereto, together with the pairs of sprocket wheels which are driven by worm gears and engage with the clip driving chain. For this purpose, the control drive chains may be subdivided within the individual treatment zones into various sections moving at differing velocities adjusted to the duration of the particular treatment step. This means that the stretching zone and fixing zone have one control drive chain each while the heating-up zone has no control drive chain. For returning the individual clips, such control drive chains are arranged only on the return path of the clips, ahead of a driving and deflecting wheel.

The clip driving device may be reinforced as required in the region of action of the driving wheel compared with the region engaging with the pairs of sprocket wheels. Due to the arrangement of two contra-rotating worm gears in the clips, the forces produced cancel each other out so that the occurrence of shear forces is prevented.

Embodiments of the invention will now be described with reference to the drawings, in which:-

Figures 1a and *1b* are top plan views of apparatus for biaxial stretching of a foil web;

Figures 2a and *2b* are vertical sections through a guide track having a tentering clip, a control sprocket wheel and a worm gear (Figure 2a) and a traction device with mitre or bevel gear (Figure 2b);

Figures 3a and *3b* are top plan views of the tentering clip with control sprocket wheel and worm gear (Figure 3a) or bevel or mitre gear (Figure 3b) and a traction device according to Figures 2a and 2b;

Figure 4 shows a portion of Biflex gear chain in engagement with pairs of sprocket wheels;

Figure 5 shows flexible belts in engagement with the pair of sprocket wheels; and

Figure 6 shows a number of tentering clips arranged in a row on a traction device.

Referring to the drawings, the apparatus according to Figures 1a and 1b is arranged symmetrically about the mid-line *m* of the foil web to be treated. The mode of operation of the apparatus will therefore be described with reference to one side only of the web. Identical parts are marked with the same reference numerals in Figures 1a and 1b; modified parts or parts with a different action are marked with a dash in Figure 1b. The apparatus shown in Figures 1a and 1b differ only in the arrangement of the control gear elements.

Figure 1a is a schematic partial representation (left half viewed in the direction of travel) of an apparatus for biaxial stretching of a foil web, seen from above. The apparatus comprises two guide tracks 1 which are arranged symmetrically about the mid-line *m* of the foil web 2 and, viewed in the direction of travel of the web 2 (see direction of arrow on line *m*) extend parallel to each in the region of a foil input 3 and a heating zone 4 up to the beginning of a stretching zone 5, and diverge in the stretching zone 5. Starting at the transition from the stretching zone 5, the guide tracks 1 again extend parallel, or slightly converging (broken lines), in a fixing zone 6 as far as the exit 3' of the web 2 from the apararus. Individual tentering clips 10, which are arranged side by side with varying degrees of closeness, are carried by a traction device 9 (e.g. a multiple roller link chain) illustrated in the upper part of the figure, which travels along the guide track 1 and is guided over driving and deflecting wheels 7, 8. In the heating zone 4, the clips 10 are caused to be close together. Due to the continuous increase in width or length of the web 2 as determined by the given stretching ratio during passage of the web through the stretching zone 5, and in order to avoid damage to the web 2, the distance between the individual clips 10, which have hitherto been close together, is increased. This increase in distance (a, a_1, a_2, a_3,) is brought about by control elements 11 arranged beside the guide track 1, and subdivided into sections, if necessary, cooperating with a control sprocket wheel 12, disposed at each clip 10 and engageable with the relevant control element 11, and a transmission connected with each sprocket wheel. The transmission is seen in Figures 2a, 2b and 3a, 3b. Each control element 11 comprises a revolving drive chain driven externally at adjustable speed. The drive means has been omitted for the sake of clarity. The locations of these drive chains 11, the extent to which they are used, and the speed at which they are driven, are chosen as required to produce the necessary change in distance between clips to conform to the required longitudinal stretching ratio at any given point.

When the given stretching ratio has been reached so that stretching is complete, the foil web 2 travels into the fixing zone 6 following the stretching zone 5. At that stage, adjacent clips 10 are still at their maximum distance apart, but since the web 2 shrinks during fixing, the distance between clips must be adjusted according to the amount of shrinkage if the stretched foil web 2 is to be undamaged. This adjustment is made by at least one second, externally driven control drive chain 15 which is arranged along the track 1 and is independent of the first control drive chain 11. The drive chain 15 also meshes with control sprocket wheels 12, but is driven at a different speed. To restore the positions of the clips 10 which have been carried round the deflecting wheel 8 by the traction device 9, a third control drive chain 16 is provided next to the guide track 1 near the driving and deflecting wheel 7. This drive chain 16 is driven at yet another speed.

Figure 1b is a schematic partial representation of the right half of an apparatus which is a slight modification of that of Figure 1a. Whereas in Figure 1a a drive chain 16 subdivided into sections is provided beside the guide track 1 near the driving and deflecting wheel 7 for resetting the clips 10, the clips 10 in Figure 1b are close together as they pass on to the driving and deflecting wheel 7. This reduction in distance between clips is brought about by an undivided control drive chain 16' beside the track 1 immediately downstream of the wheel 7 and extended substantially over the length of the heating zone 4. A braking action is thus applied to the clips 10 leaving the wheel 7, and after entry into the stretching zone 5 the clips are re-set by additional drive chains 11' subdivided into sections until the fixing zone 6 is reached, where a continuous drive chain 15' provides that no further change in spacing

takes place. The clips 10 thus travel more slowly than the traction device 9, according to the stretching ratio in the heating zone 4.

Displacement of the clips 10 on the traction device 9 will now be described. As seen in Figures 2a and 2b, a clip 10 is supported and guided by support and guide rollers 17, 17' and 18, 18'. In Figure 2a, a self-locking double worm gear 13 is arranged in the lower part of the clip 10 and is driven by a sprocket wheel 12 arranged laterally thereto and in engagement with one of the control drive chains 11, 15 or 16. The double worm gear 13 drives two pairs of rotating sprocket wheels 14 arranged horizontally and one above the other, each pair by way of a shaft 19 perpendicular to the axis of the worm gear 13. Instead of the worm gear 13, a bevel or mitre gear 13' with single or double arrangement of gear wheels could be provided, Figure 2b. An arrangement using planet or cyclo gears (not shown) could also be used.

Both pairs of sprocket wheels 14 are arranged with their teeth 20 engaging upper and lower or outer links of a multiple roller link chain, i.e. the traction device 9. When the sprocket wheels 14 rotate, the clip 10 is displaced on the traction device 9 either forwards or backwards depending on the sense of rotation of the wheels 14, and the distance between clips 10 is thereby adjusted and controlled (see also Figure 3a). The traction device 9 is driven by a driving wheel engaging with the links 23 of the traction device 9 between the pairs of sprocket wheels 14. Various known types of conveyor chains or belts with teeth may be used as the traction device. The use of so-called Biflex gear chains which have teeth on both sides is advantageous.

A clip 10 with a clamping element 22 carried along a guide track as described with reference to Figures 2a and 2b is seen from above in Figures 3a and 3b. The guide track is here indicated by two vertical dash-dot lines representing the track rails which support the guide rollers 18 and 18' and take up horizontal forces. The sprocket wheel 12 engaging with the drive chains 11, 15, 16 transmits the forces of adjustment and displacement for increasing or decreasing clip spacing to the traction device by way of the contra-rotating double worm gear 13 (Figure 3a) connected to the clip 10, or by way of a bevel or mitre gear 13' (Figure 3b), the drive shaft 19, and the teeth 20 of the sprocket wheels. The sprocket wheels 14 engage pairwise with the upper and lower parts of the traction device 9 from opposite sides. This symmetrical arrangement avoids production of shear forces and ensures smooth displacement of the clips.

As the clips 10 are directly arranged on the traction device 9, the clamping elements 22 can be limited in size to maximally half the width of a clip 10. The clips are relatively narrow and tall. In Figures 3a and 3b, one clip 10' is indicated as a rectangle in dash-dot lines next to the clip 10 which is illustrated in detail. To prevent the clip 10 from rotating and tilting about its vertical axis, two of the guide rollers 18 of each clip, which take up horizontal forces, are arranged one behind the other in the direction of transport of the traction device 9. Since the clip 10 is quite narrow, however, the two guide rollers 18 extend laterally beyond the clip 10, as may be seen in Figures 3a and 3b, so that they extend into the range of the next clip 10'. In order to prevent adjacent clips obstructing each other, the guide rollers 18 and 18' are advantageously arranged alternately in pairs (18) and singly (18') on the upper and lower sides of a clip. This provides a wide base for guidance with minimum width of clip and prevents clips obstructing each other.

The traction device 9 illustrated in Figure 4 is a gear chain known as a "Biflex" chain 23, and has pairs of sprocket wheels 14 arranged one above the other engaging it, the sprocket teeth fitting into the gaps 24 in the "Biflex" chain 23, see also Figures 3a and 3b.

Figure 5 shows the engagement of the teeth of the pairs of sprocket wheels in recesses 25 in two adjacent bands 26, 26' which form the traction device 9.

Figure 6 shows schematically a row of clips on a traction device 9. In the left hand part of the figure, the clips are close together while in the right hand part they are shown with increasing spacing, a_1, a_2, a_3. This figure also shows the guide rollers 18 arranged pairwise alternating with guide rollers 18' arranged singly at the upper and lower parts of a clip.

The control drive chains which are independent of the clips have the advantage that the adjustment of their speed can be used for continuous adjustment of the amount of displacement of the clips and hence of the distance between them. If such adjustment is not necessary and it is sufficient to select the positions once and for all, the same effect may be achieved by a rigid arrangement of a toothed rack with appropriate adjustment of the control sprocket wheel and worm gear.

Using bevel or mitre gears instead of worm gears has the advantage that the control drive chains move more slowly and are less subject to wear.

Thus in the apparatus of the invention the clips are moved by an endlessly rotating traction device. The distance between the clips can be adjusted by control means arranged outside the traction device and independent of it. The relative speed between traction device and control means, which may be a driven driving chain or a rigid toothed rack, determines the speed of displacement of the clips on the traction device, which also depends, of course, on the transmission ratio of the transmission elements in the clips. In sections of the guide track where no control elements are situated, the momentary distance between two successive clips remains unchanged. The apparatus of the invention has been described above with reference to biaxial foil stretching by way of example, but it is also applicable to single stretching, e.g. in the longitudinal direction alone.

CLAIMS

1. Apparatus for stretching a foil web, comprising tentering clips driven on two guide tracks at respective side edges of the web to grip the edges,

the distance between clips being adjustably variable, and each guide track having a continuously driven clip driving device, wherein clips are connected to the clip driving device by gear elements and by which gear elements clips are adjustably displaceable in the longitudinal direction of the clip driving device, the gear elements being operable from control means arranged along the guide track and independent of the clips.

2. Apparatus according to claim 1 wherein each clip driving device is a chain and the gear elements include sprocket wheels mounted in a clip and engaging the chain.

3. Apparatus according to claim 2 having a pair of sprocket wheels at each side of the chain, the sprocket wheels of each pair being rigidly mounted one above the other on a vertical shaft, whereby the teeth of sprocket wheels of each pair engage the chain from opposite sides.

4. Apparatus according to claim 3 wherein the shafts are rotated from a common gear wheel by way of a contra-rotating transmission, which common gear wheel is in mesh with the control means.

5. Apparatus according to any preceding claim wherein the control means is subdivided into several sections.

6. Apparatus according to any preceding claim wherein the control means or each section thereof comprises a rotating control drive chain.

7. Apparatus according to claim 6 wherein the control drive chain is drivable at adjustably variable speed.

8. Apparatus according to any of claims 1 to 5 wherein the control means are rigid gear elements.

9. Apparatus according to claim 2 wherein the chain is a roller link chain.

10. Apparatus according to claim 2 wherein the chain is a conveyor chain.

11. Apparatus according to claim 2 wherein the chain is a "Biflex" gear chain.

12. Apparatus according to claim 1 wherein the clip driving device comprises perforated strips.

13. Apparatus according to claim 3 wherein the drive to the chain takes place between a pair of sprocket wheels.

14. Apparatus according to claim 4 wherein the contra-rotating transmission includes a worm drive means.

15. Apparatus according to claim 14, wherein the worm drive means is self-locking.

16. Apparatus according to claim 4 wherein the contra-rotating transmission includes bevel or mitre gears with or without lock.

17. Apparatus according to claim 1 wherein a planet or cyclo gear is provided in each clip.

18. Apparatus according to any preceding claim wherein the width of the clamping elements of a clip is at the most half the width of the clip.

19. Apparatus according to any preceding claim wherein each clip has guide rollers which are arranged alternately pairwise and singly in the upper and lower parts of the clip.

20. Apparatus for stretching a foil web constructed and arranged substantially as herein described and shown in the drawings.

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